



How Complimentary are SRTM X- and C-band data?

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German Remote Sensing Data Center (DFD)**

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- **Comparing the two SRTM DEMs**
 - ➔ **Completeness**
 - ➔ **Differences**
 - ➔ **Accuracy**
- **Merging C- and X-band data**
- **Analyzing the improvements**



SRTM – Elevation Models

SRTM C-

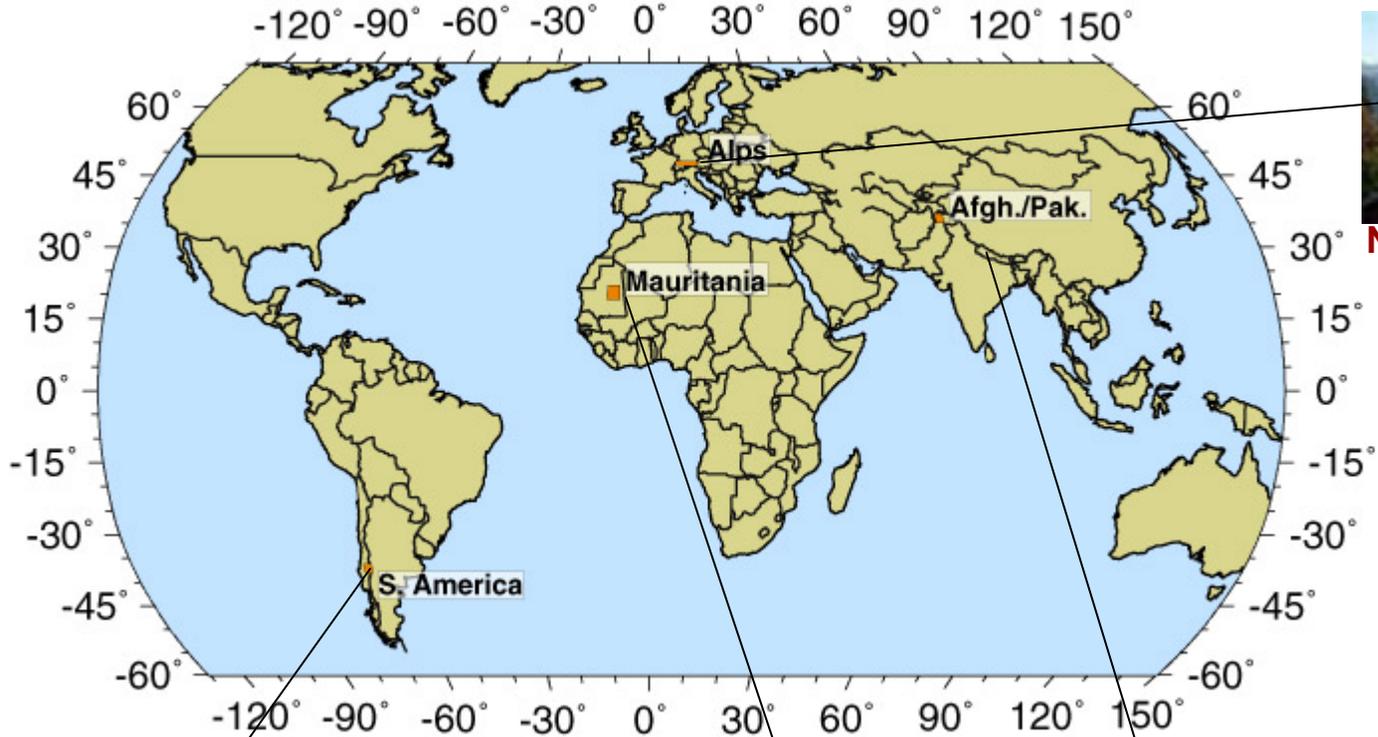
Parameter	Band	SRTM X-Band
wavelength	5.6 cm	3.1 cm
carrier frequency	5.3 GHz	9.6 GHz
polarization	Dual	VV
incidence angle (center)	45°	55°
swath width	225 km	50 km
relative vertical accuracy ¹	10 m	6 m
absolute vertical accuracy ¹	16 m	16 m
relative horizontal accuracy ²	15 m	15 m
accuracy ²	20 m	20 m
elevation steps	1 m	1 m
grid raster size	1" (30m)	1"
vertical datum	EGM96	WGS84 o. MSL
horizontales datum	WGS84	WGS84

¹ 90% vertical error
² 90% circular error

What can be gained by combining both DEMs?



Test areas



Northern Alps



South America



Mauritania



Afghanistan



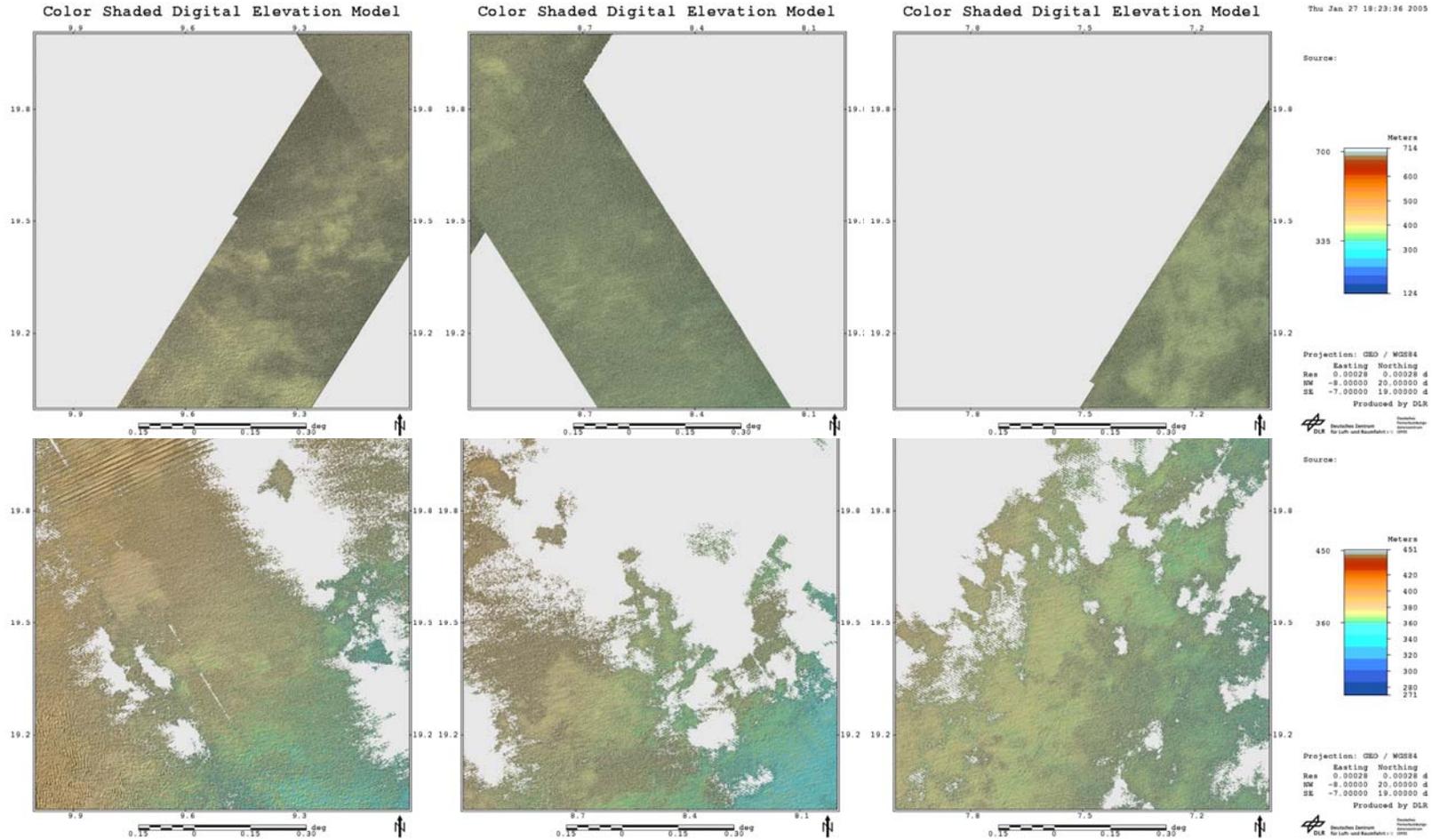
Relative comparison of X- and C-band DEMs



- **C-band is more complete than X-band:**
 - **X-band: 40%**
 - **C-band: 80%**



Relative comparison of X- and C-band DEMs



- Void regions are distributed differently in the two DEMs

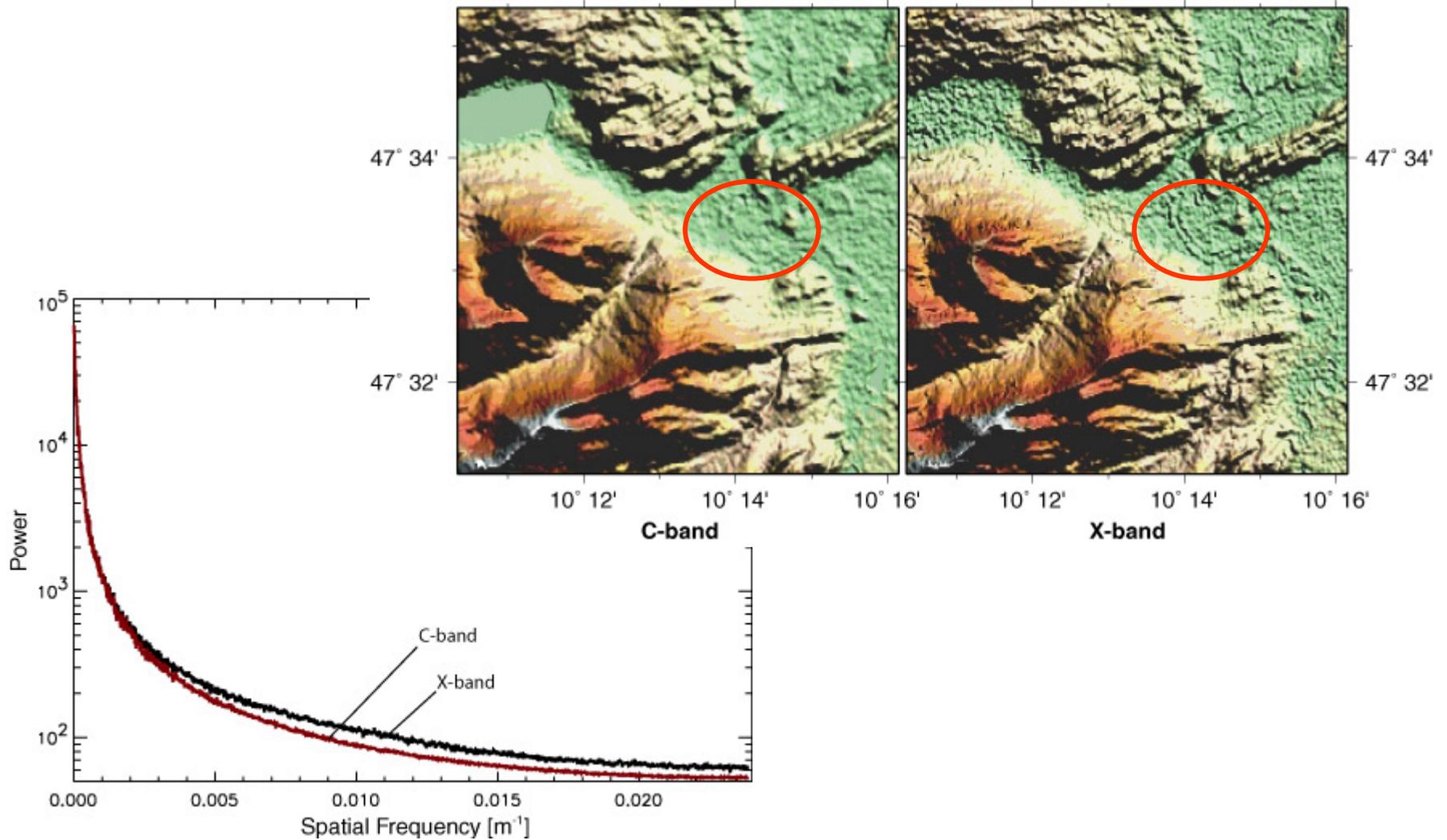


Completeness can be improved significantly

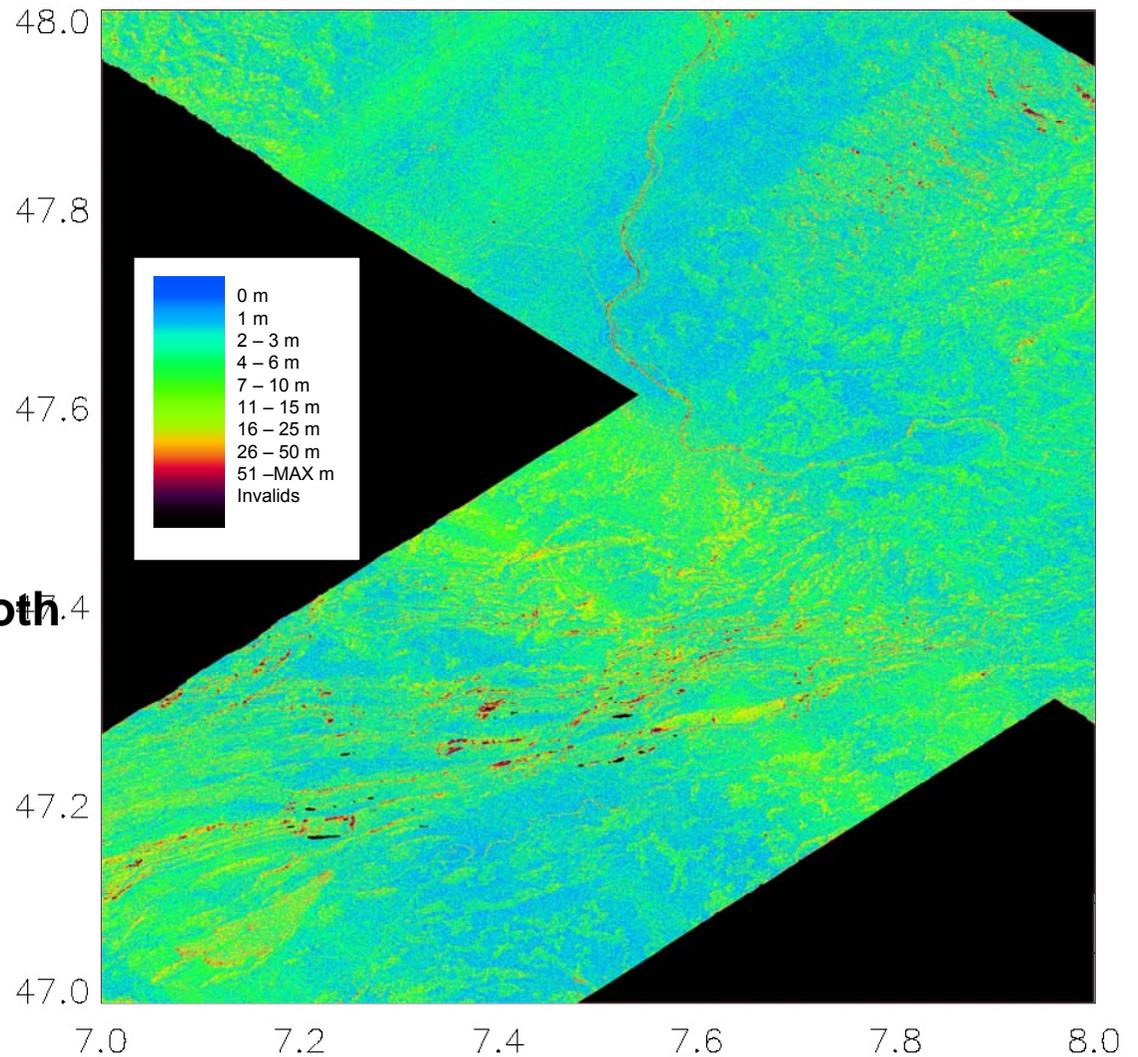
Test area	Invalids C-band	Invalids X-band	No acquisition in X-band	Holes fillable in C-band	Invalid in C- and X-band
Northern Alps	2.3%	0.0%	34.3%	52.7%	1.1%
Afghanistan	20.4%	6.0%	59.4%	22.2%	16%
Mauritania	40.1%	0.0%	66.8%	29.3%	29.8%
South America	0.3%	0.0%	44.4%	36.7%	0.1%



C-band DEM is smoother than X-band DEM



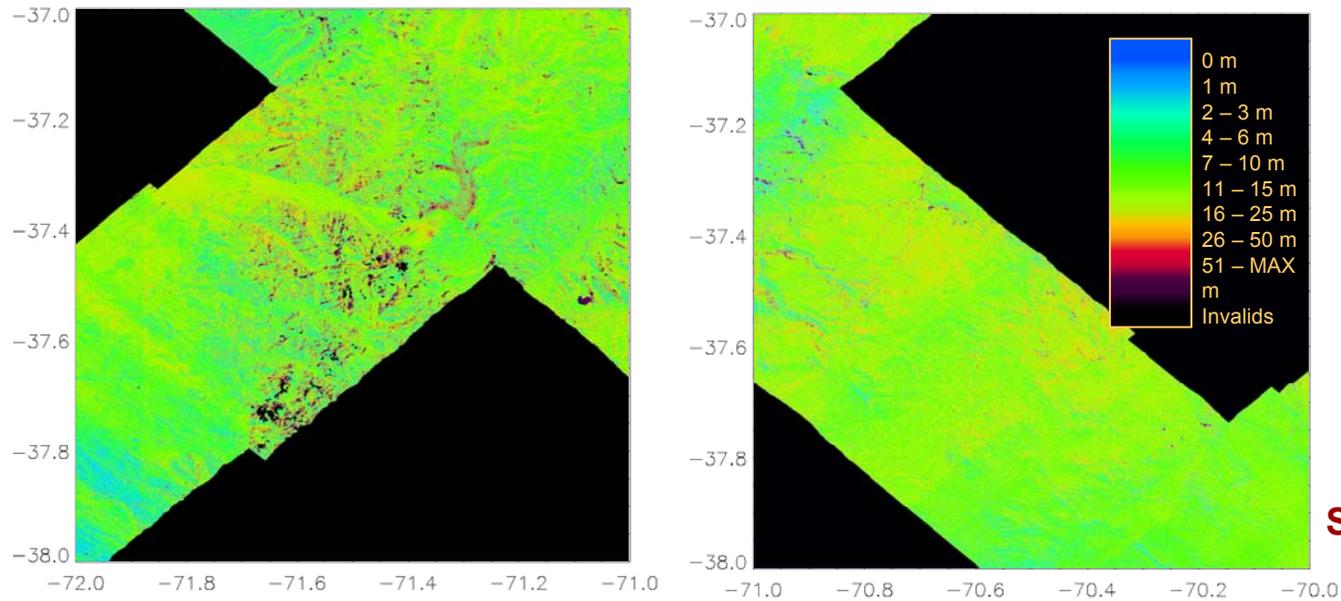
Differences between C- and X-band are small



- **Slight differences occur both at large and small scales**
- **Problems particularly on:**
 - **steep slopes**
 - **water bodies**



Large-scale offsets can be many meters



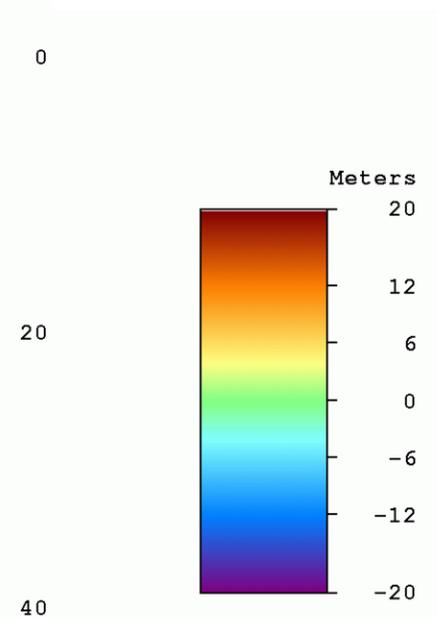
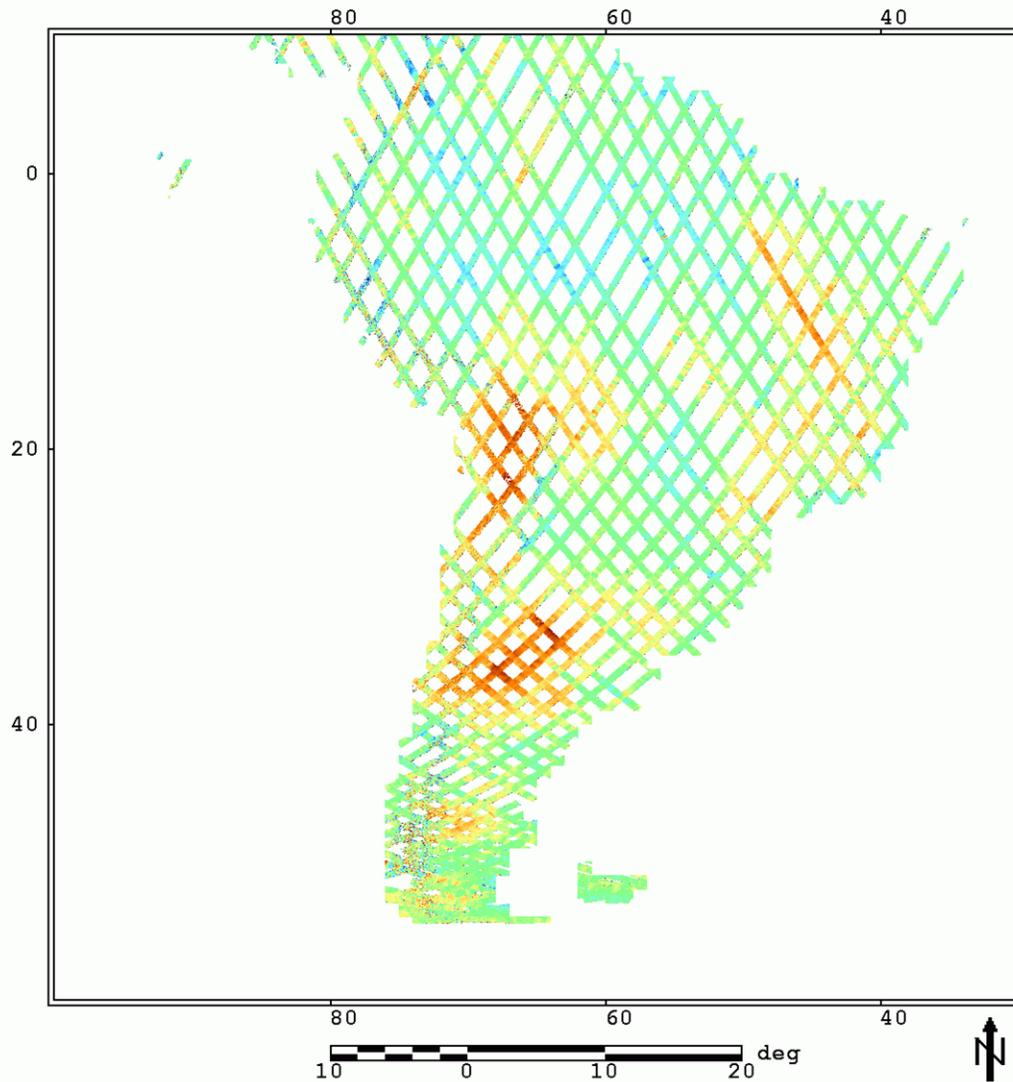
- In some regions, low-frequency offsets occur





Large-scale offsets can be many meters

Colored Digital Elevation Model



Projection: GEO/WGS84 NN
Easting Northing
Res 0.06667 0.06667 d
NW -100.00000 10.00000 d
SE -30.00000 -60.00000 d
Produced by DLR

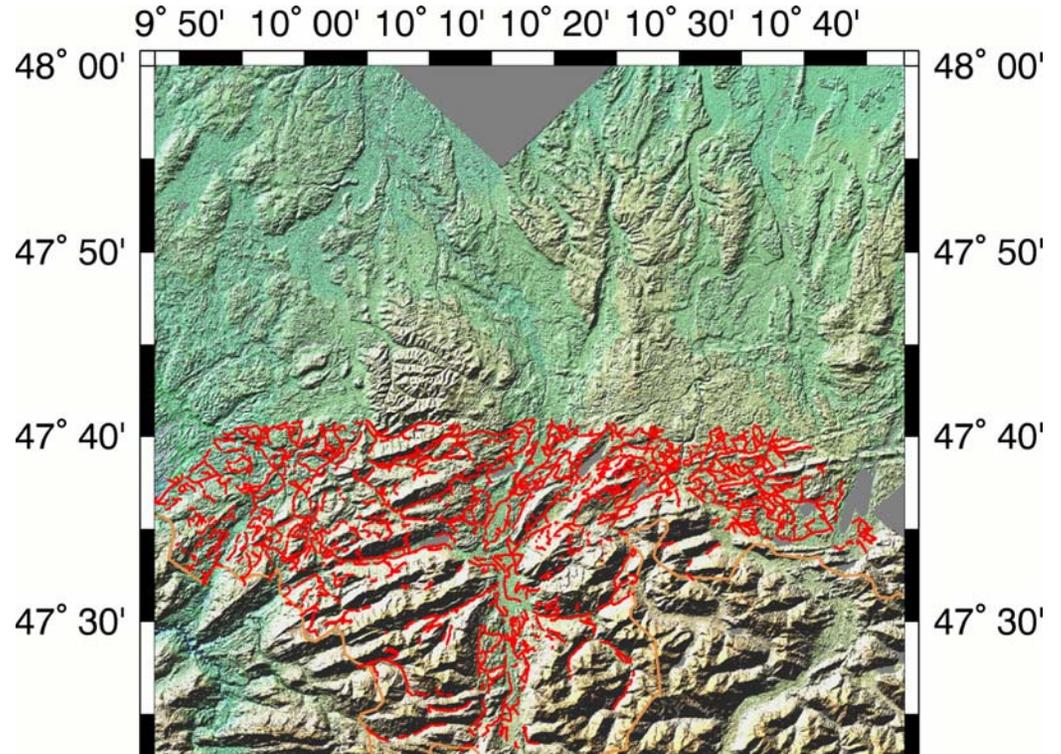


Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR)
Deutsches Fernerkundungsdatenzentrum (DFD)

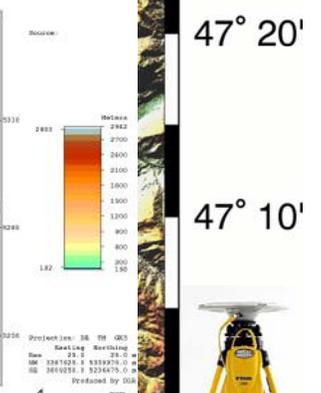
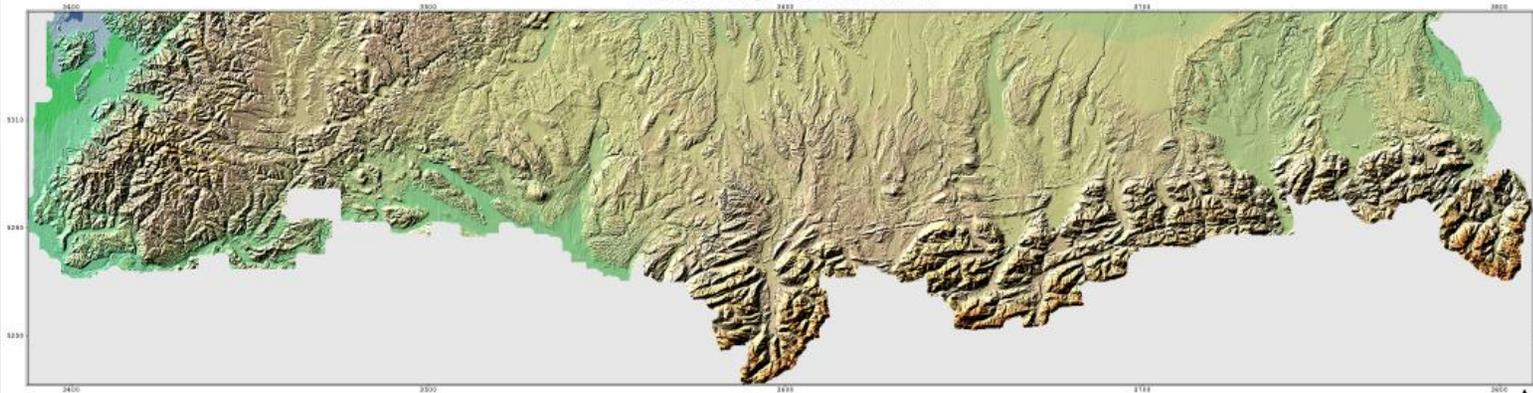


Accuracies in the test area Northern Alps

- Two types of reference information:
 - ➔ **GPS-Tracks**
 - $\sigma \sim m$
 - Profile information
 - WGS 84
 - ➔ **DGM-D 25**
 - $\sigma \sim 10m$
 - Area information
 - Gauss-Krüger

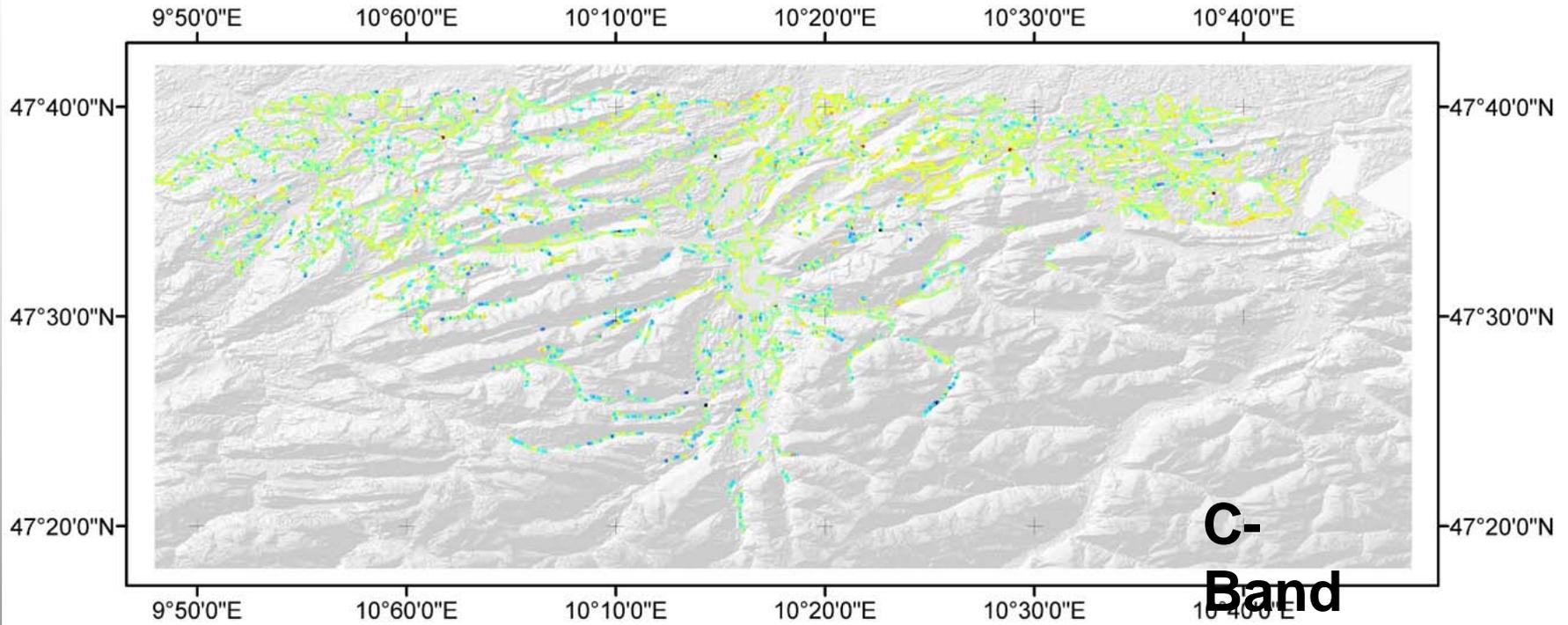


Color Shaded Digital Elevation Model

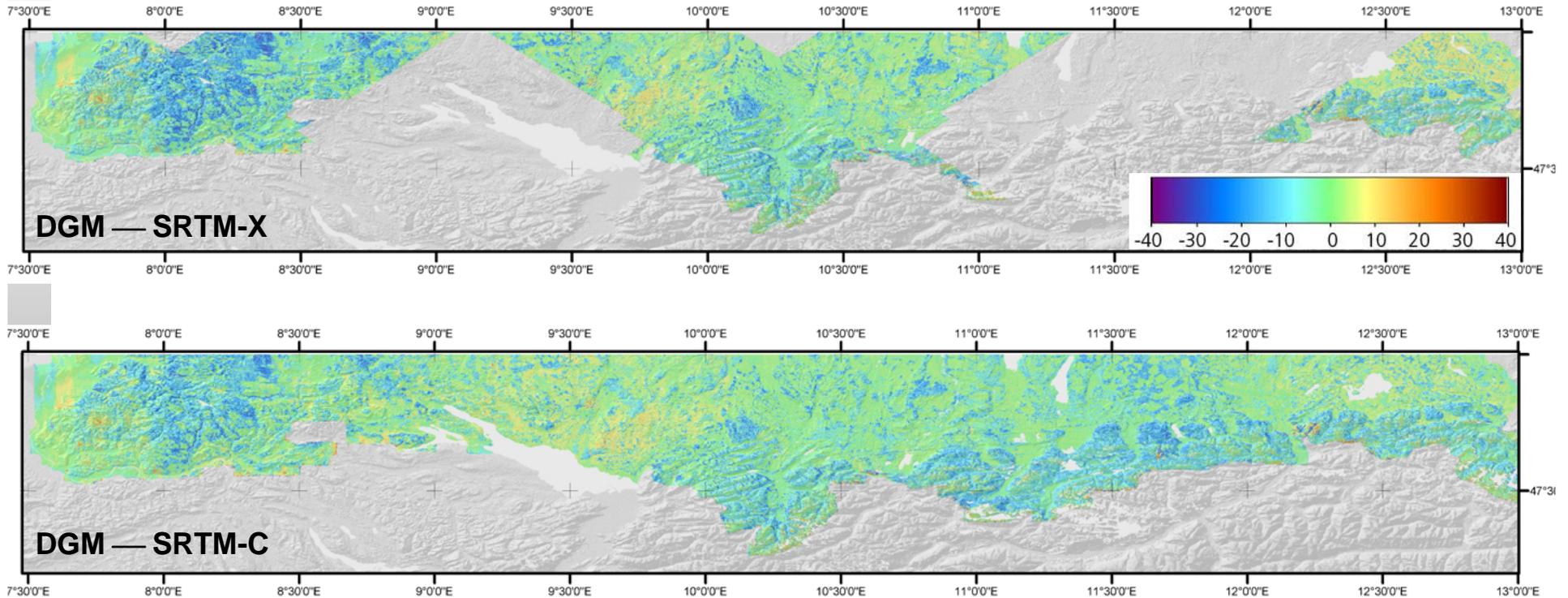




Absolute accuracies of C-/X-band are comparable



Comparison between reference model and SRTM

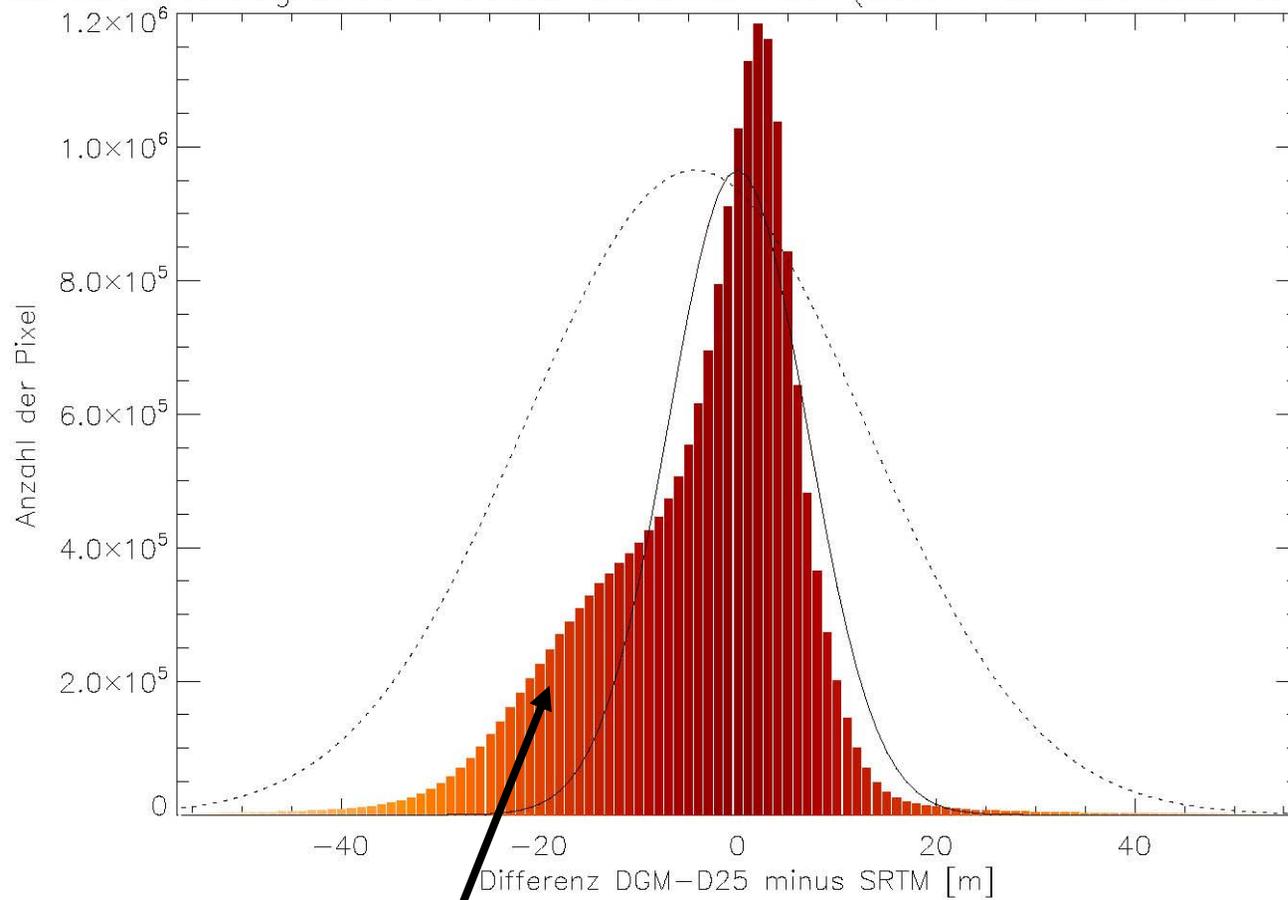


- SRTM-DEMs more similar to each other than to reference
- On average, SRTM-DEMs slightly too high



Statistics reveals difference between DSM and DEM

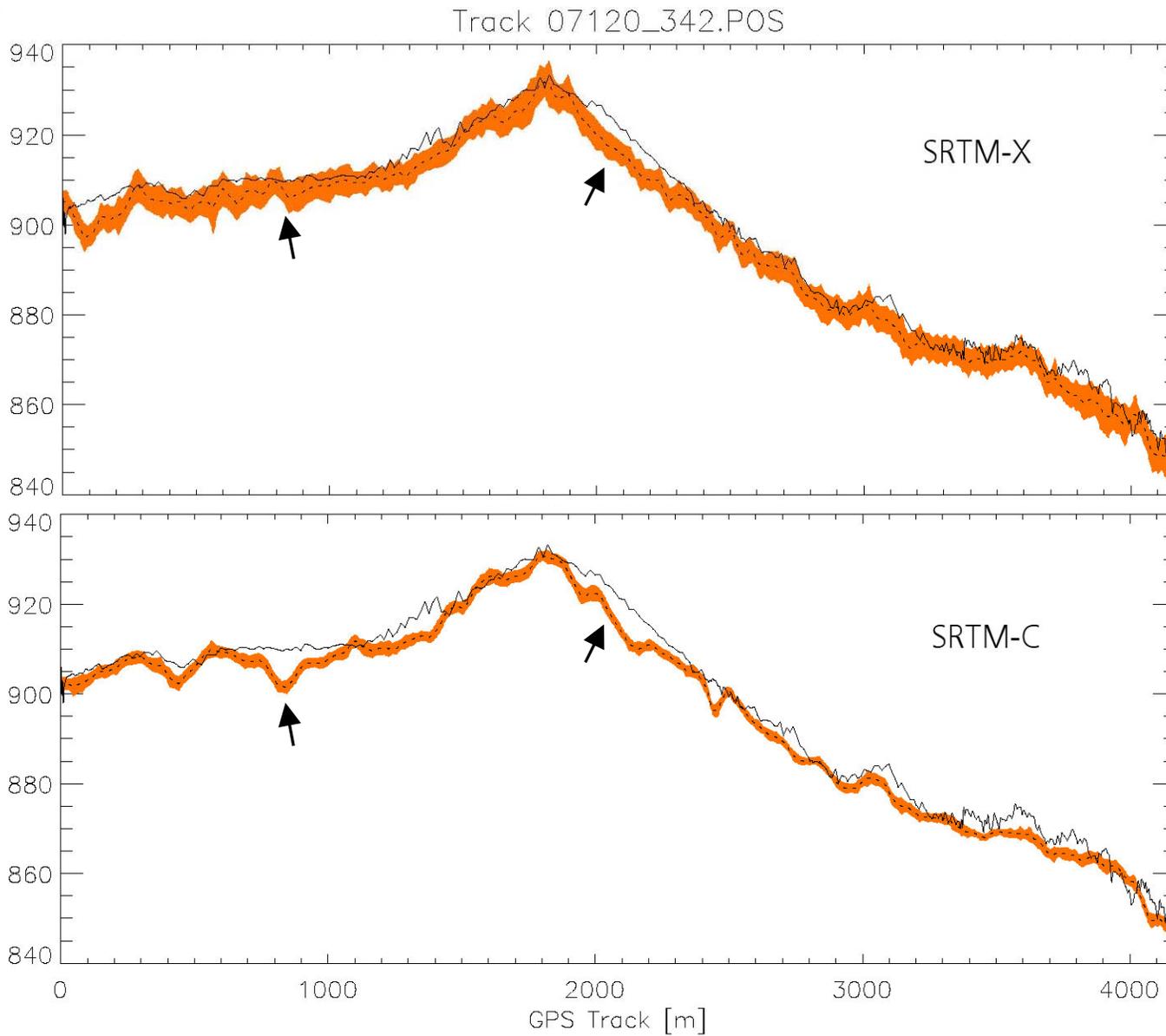
99% Zoom Histogramm & Gauss-Dichtefunktion (Daten: hist_diff_DGM_XDHM_537cm)



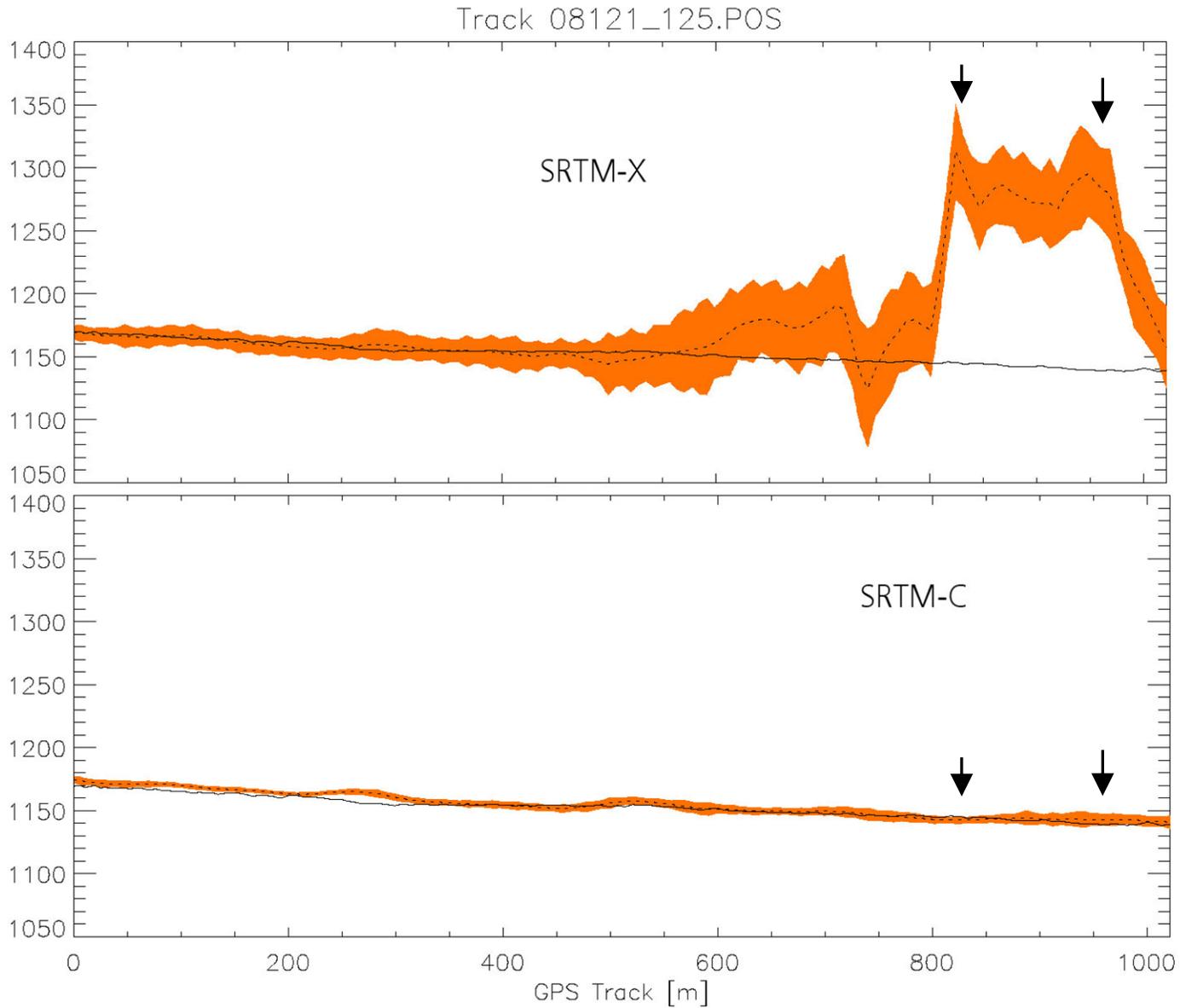
Vegetation / houses



C-band DEM is smoother

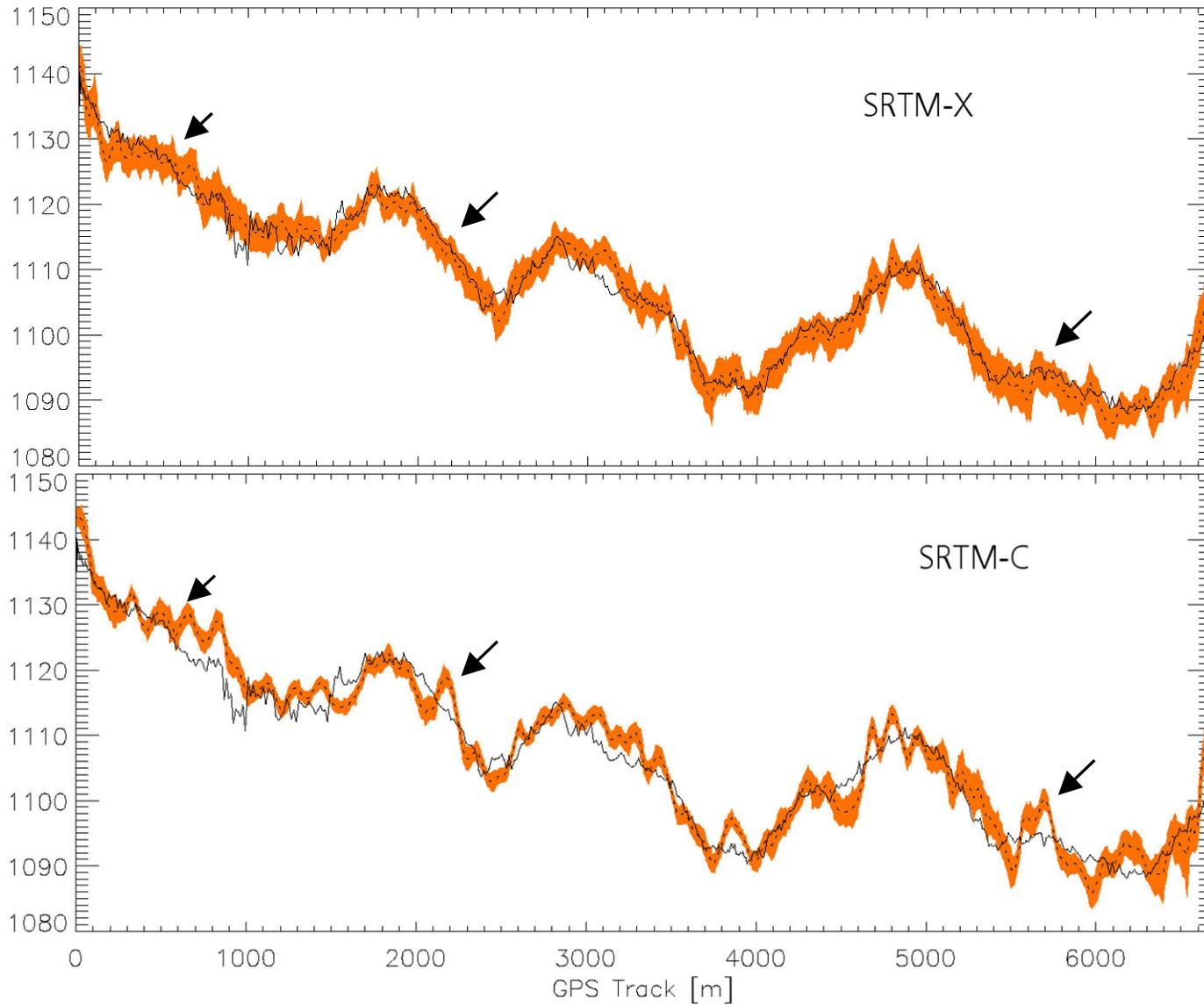


X-band DEM contains more unwrapping errors

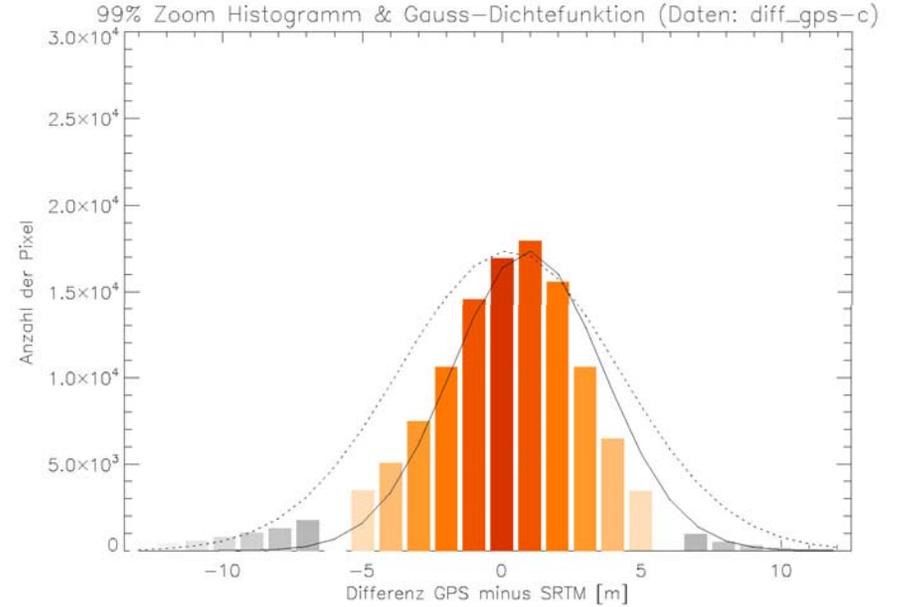
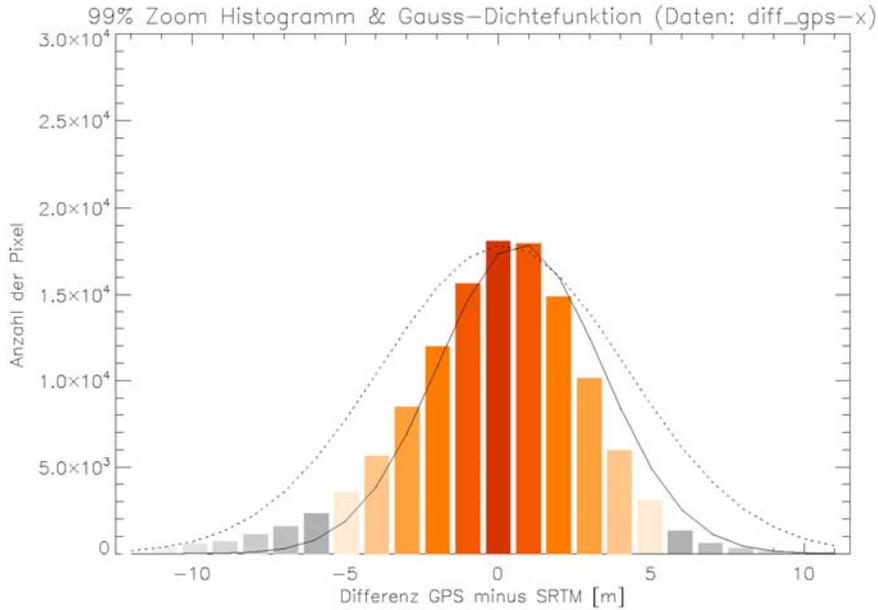


Quality of C- and X-band are similar

Track 08121_108.POS



Quality of C- and X-band are similar



- **Only minimal statistical differences of absolute accuracies in test areas**

	X-Band DHM	C-Band DHM
Minimum [m]	-167,82	-45,39
Maximum [m]	53,52	52,04
Mean [m]	0,17	0,26
Standard deviation [m]	3,99	3,90
Median [m]	0,55	0,73
99,9% of differences [m]	± 24	± 21
99,0% of differences [m]	± 12	± 13
90% of differences [m]	± 5	± 5
68% of differences [m]	± 2	± 3
50% of differences [m]	± 1	± 2

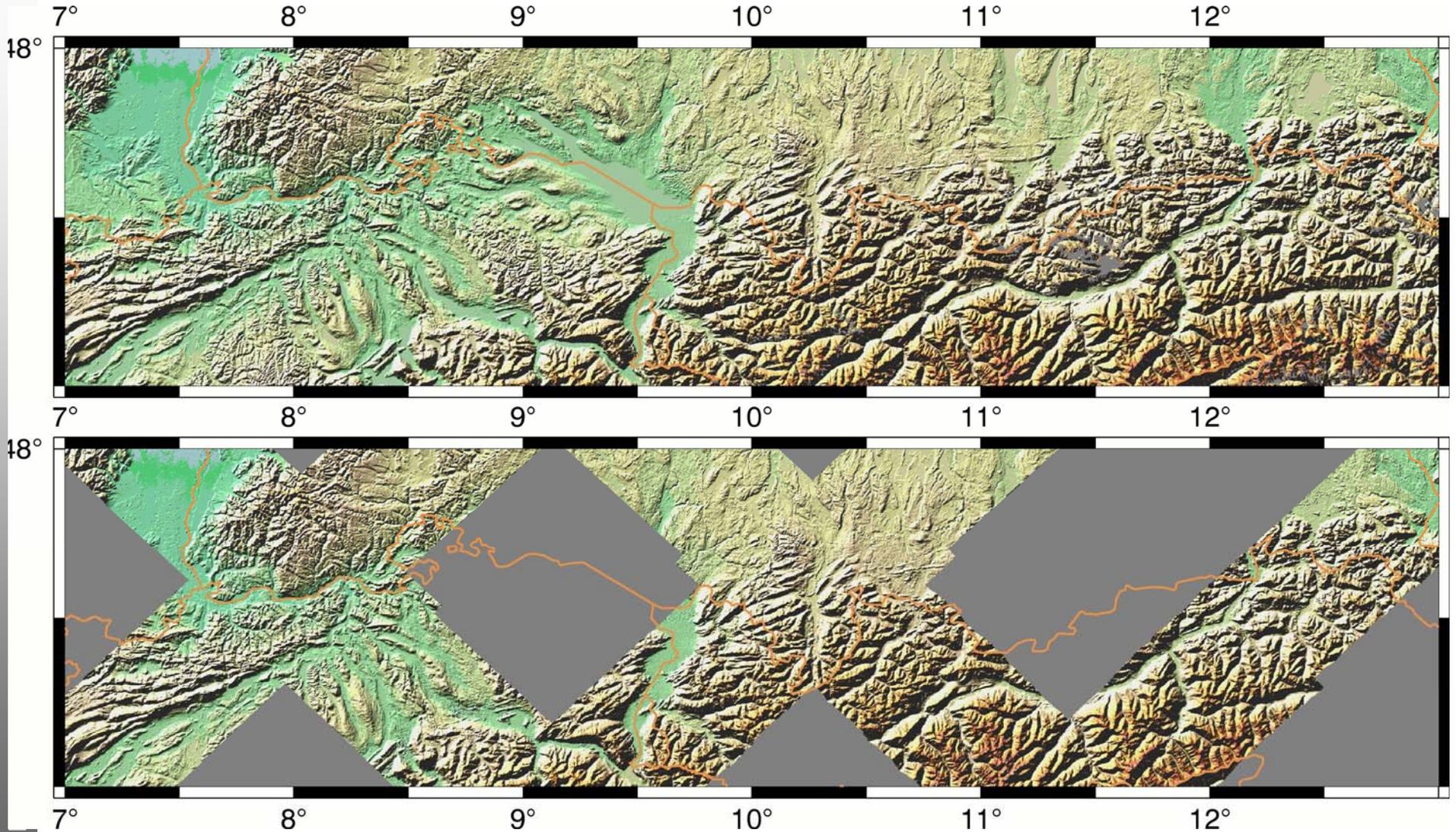


- **Masking water bodies in X-band DEM**
- **Detecting and masking outliers in X-band DEM**
- **Removal of constant offset**
- **Weighted average using error information**
- **Error propagation**





Result: Northern Alps

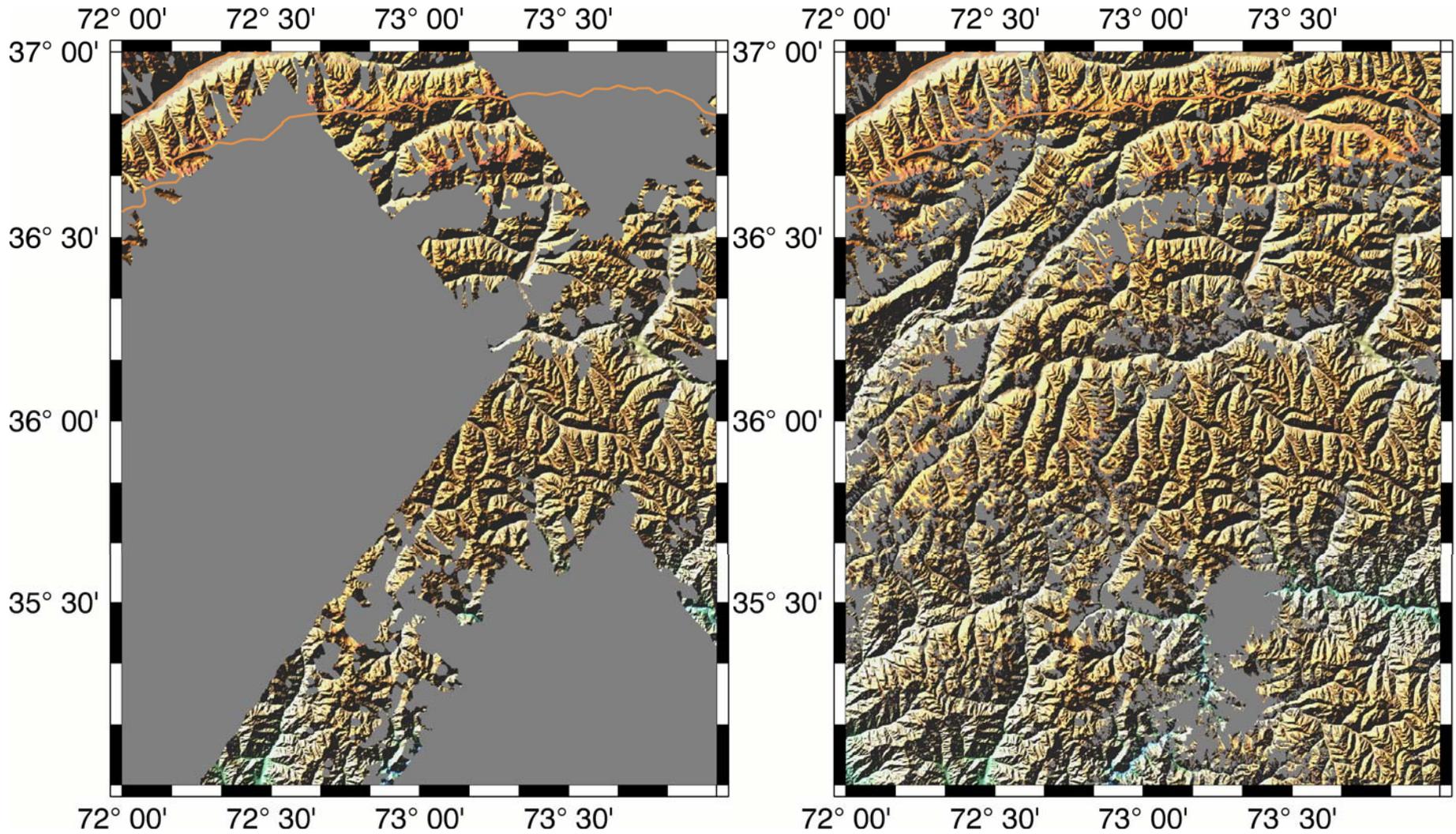


German





Result: Afghanistan

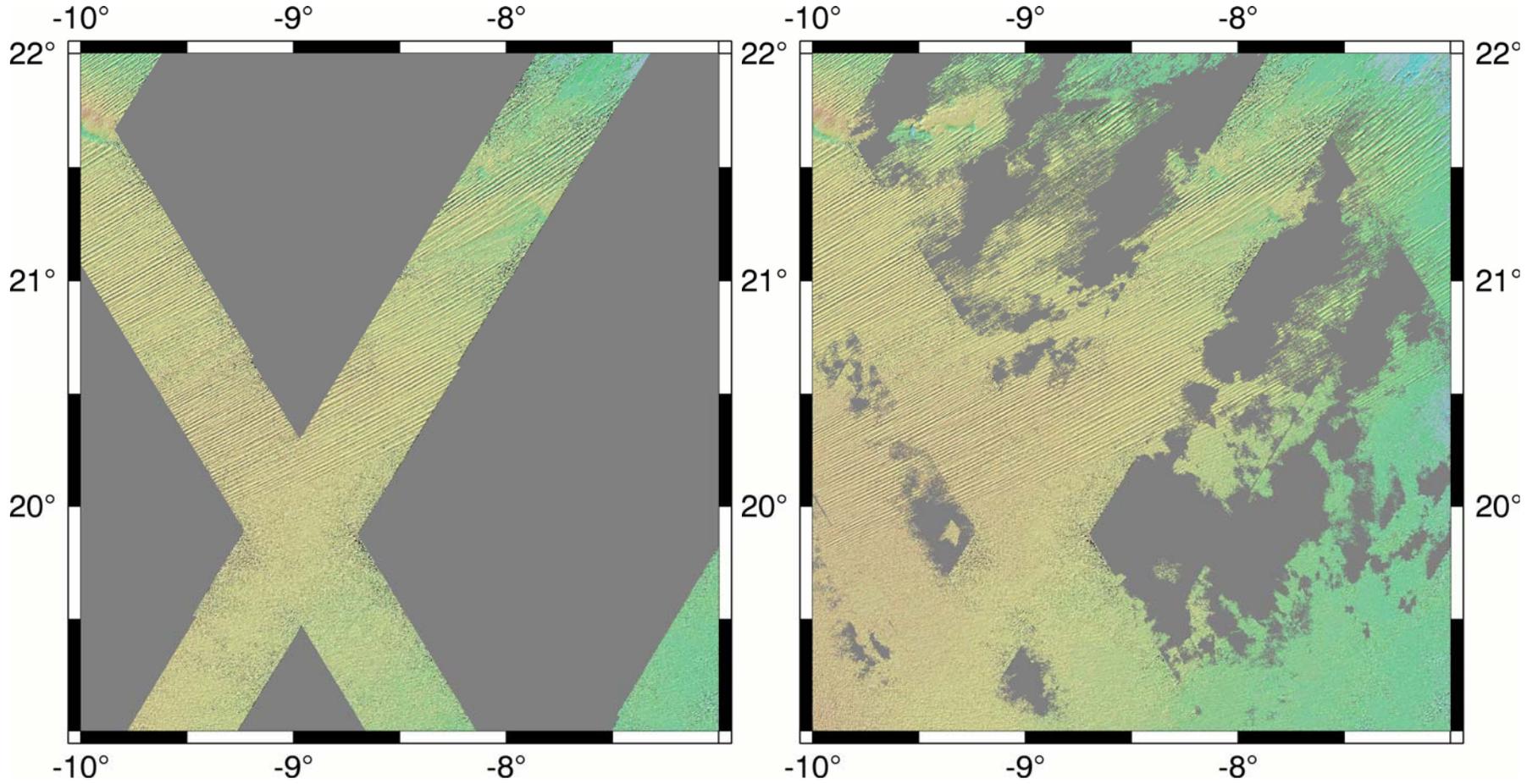


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Result: Mauritania

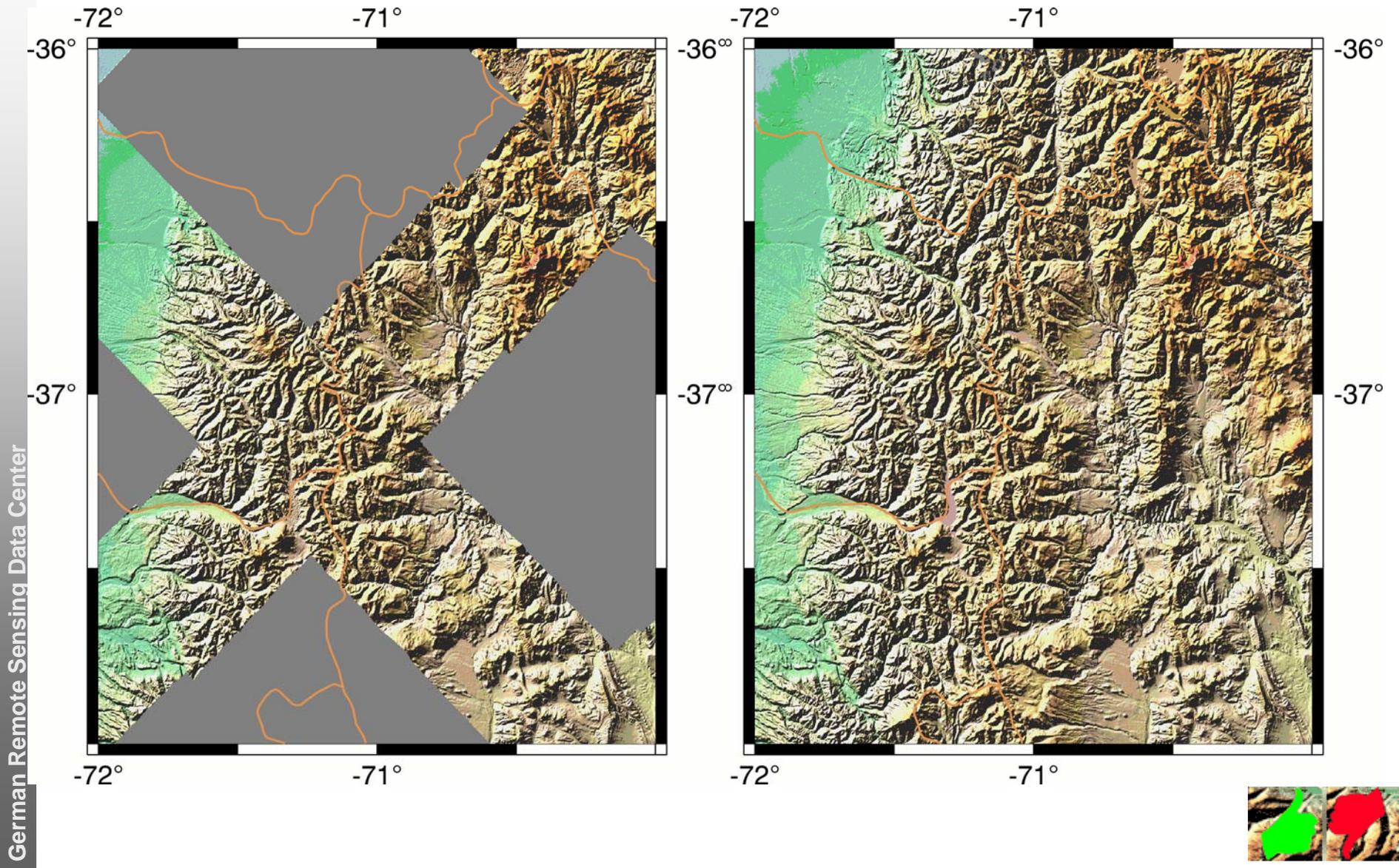


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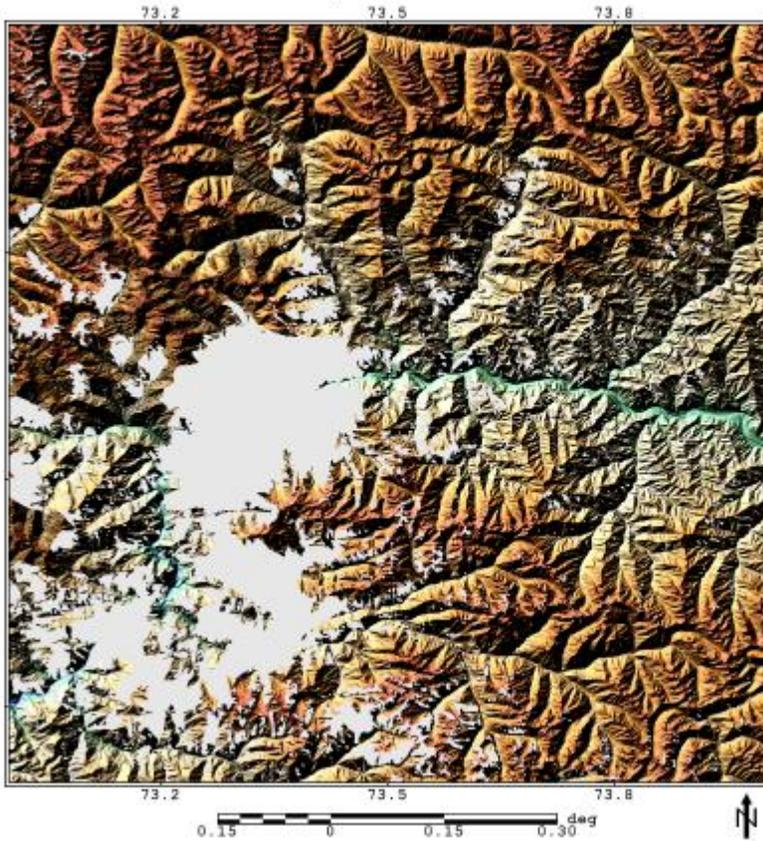
Result: South America



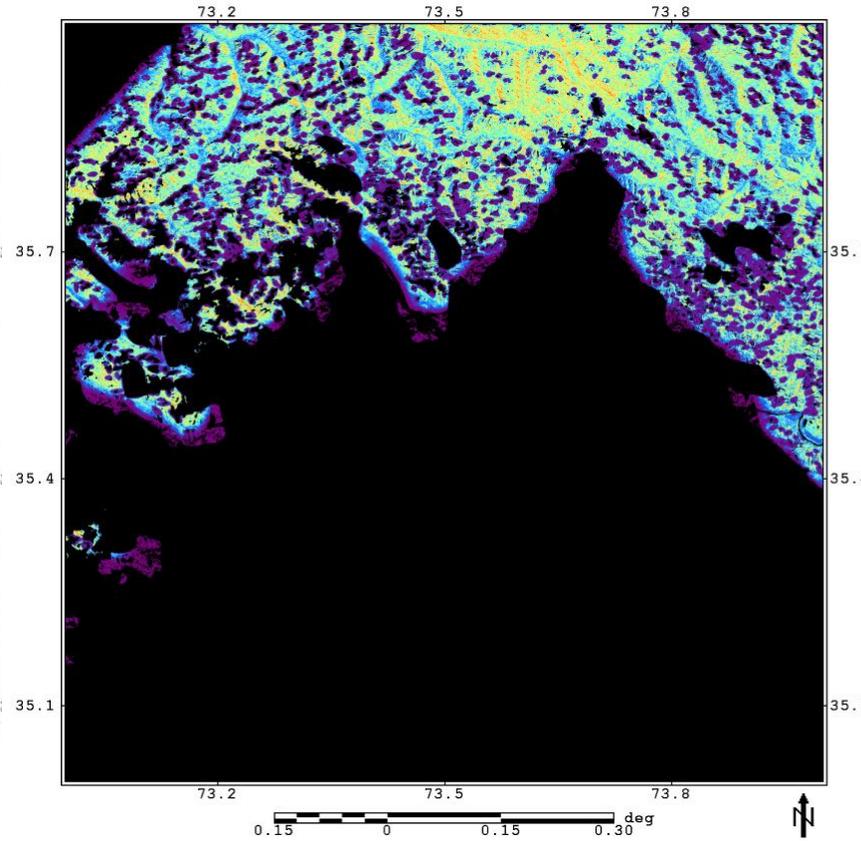


Statistical Errors decrease

Color Shaded Digital Elevation Model

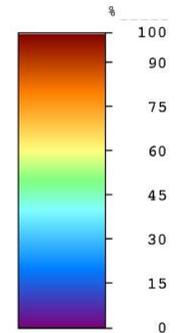


Percent Improvement over C-Band



Tue Apr 19 14:56:32 200

Source:



Projection:
Easting Northing
Res 0.00028 0.00028
NW 73.00000 36.00000
SE 74.00000 35.00000

Produced by DL



German Remote Ser



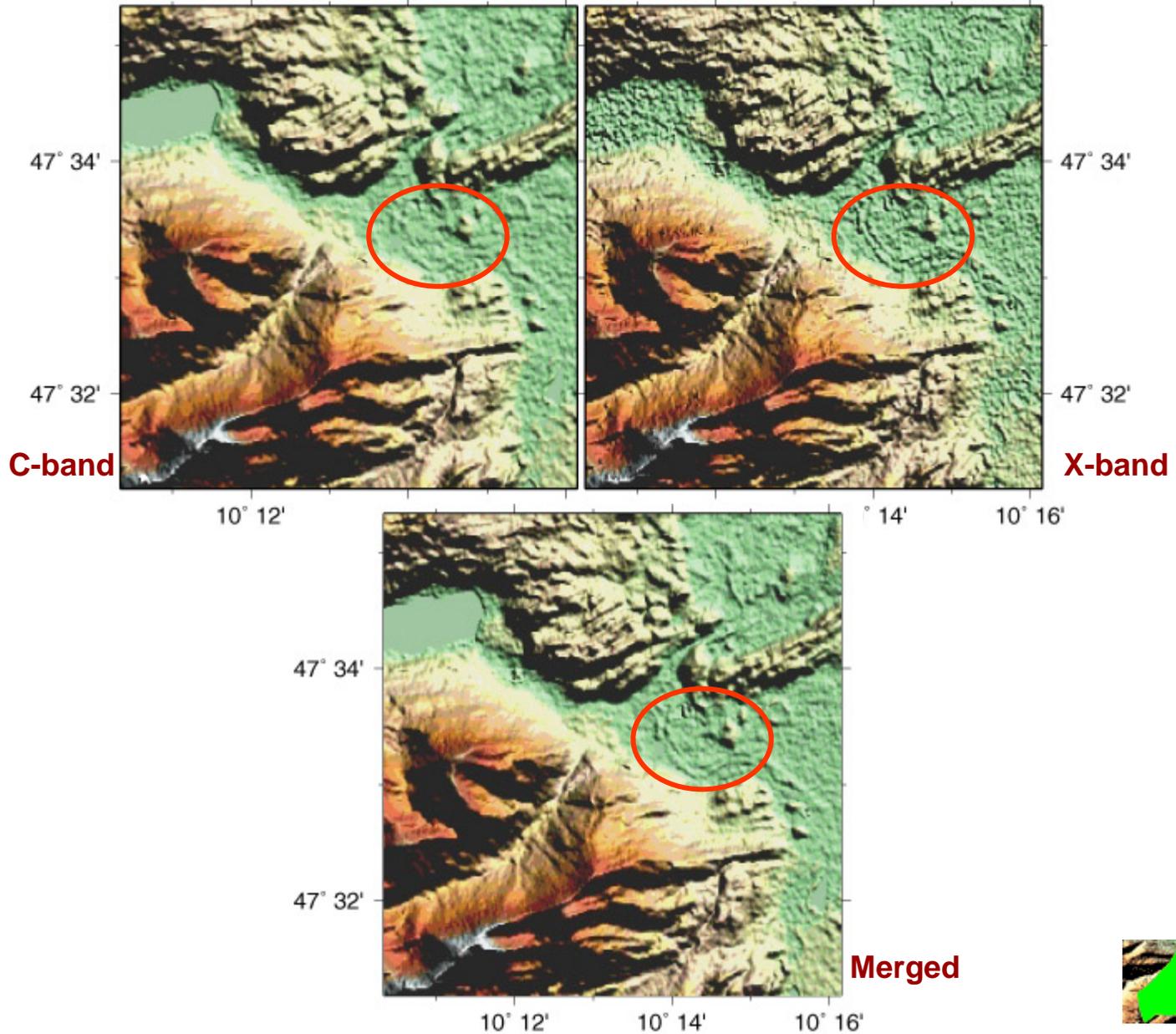
Absolute accuracy improves

	X-band DEM	C-band DEM	CX DEM
Minimum [m]	-167,82	-45,39	-45,67
Maximum [m]	53,52	52,04	52,04
Mean [m]	0,17	0,26	-0,32
Standard deviation [m]	3,99	3,90	3,39
Median [m]	0,55	0,73	0,10
99,9% of differences [m]	± 25	± 23	± 21
99,0% of differences [m]	± 12	± 14	± 13
90% of differences [m]	± 5	± 6	± 5
68% of differences [m]	± 3	± 3	± 3
50% of differences [m]	± 2	± 2	± 2

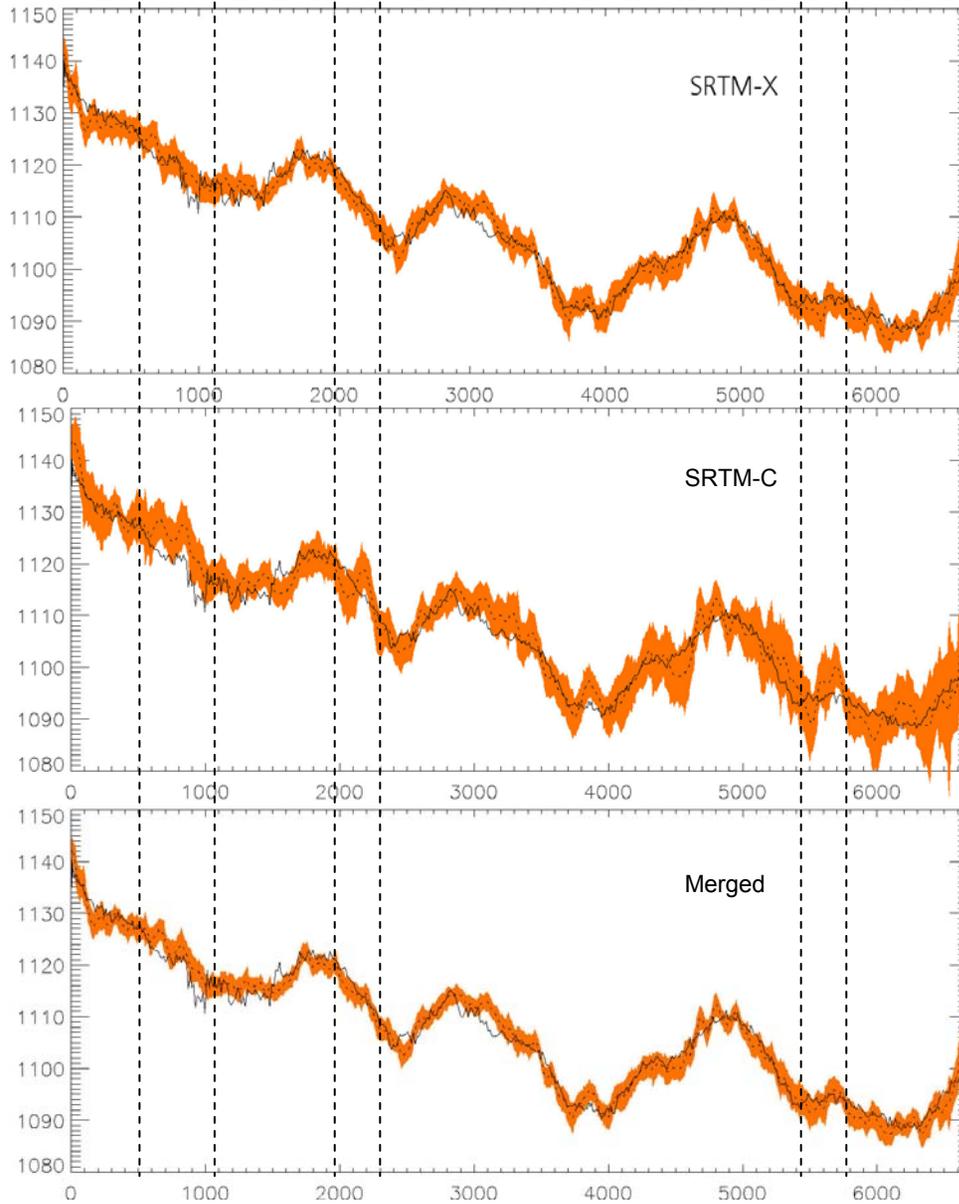
Improvement of absolute accuracy for test area Northern Alps



Merging combines characteristics of both inputs



Improvements detailed



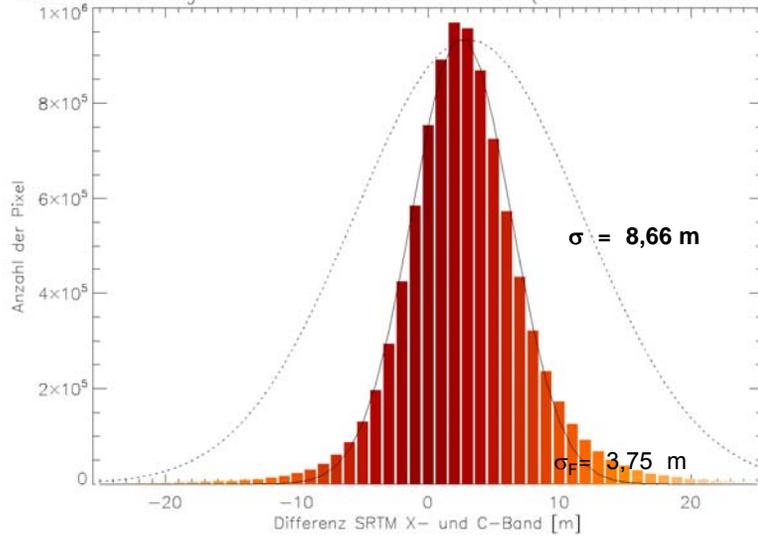
- **Improvements:**

- **Reducing deviations from reference**
- **Smaller standard error**

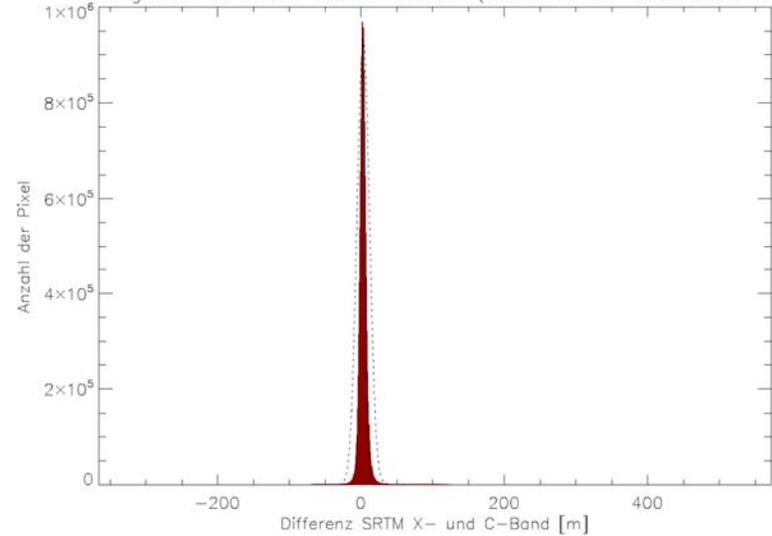


- **The DEMs derived from the C- and X-band data of the SRTM mission are of similar quality and fulfill their overall product specifications**
- **Combining both DEMs we can gain**
 - **Completeness (even at C-band)**
 - **Smaller error bands**

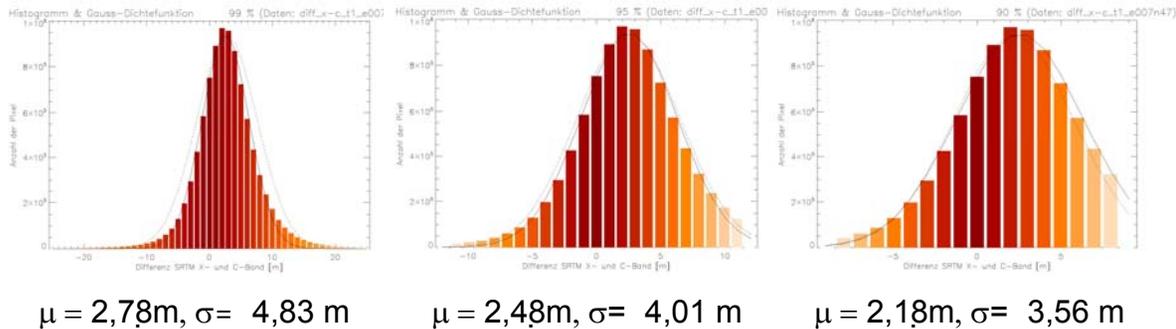
99% Zoom Histogramm & Gauss-Dichtefunktion (Daten: diff_x-c_t1_e007n47)



Histogramm & Gauss-Dichtefunktion (Daten: diff_x-c_t1_e007n47)



- Fehler scheinen nicht normalverteilt zu sein...



... sind es aber im Wesentlichen

